REMARKS

Claims 1, 2 and 4-63 are pending in this application. By this Amendment, claims 1, 12, 20, 25, 30, 35, 40, 46 and 56 are amended. Reconsideration and allowance are respectfully requested in view of the above-amendments and the following remarks.

Restriction Requirement

Claims 19, 24, 29, 34, 39, 44, 45 and 50-55 have been withdrawn from consideration.

Rejections Under 35 U.S.C. §103

1. The Final Office Action rejects claims 1, 2, 4-18, 20-23, 25-28, 30-33, 35-38, 40-43 and 63 under 35 U.S.C. §103(a) over Zhang et al. (U.S. Patent No. 5,403,772) in view of Nakamura (U.S. Patent No. 5,200,630). The Advisory Action clarifies the inconsistent record regarding the status of claims 50-55. Applicants respectfully traverse this rejection.

Claim 1 recites a method of forming a crystalline film, comprising "forming a thin film having a surface on a substrate"; and "crystallizing at least a surface layer of the thin film by applying energy to the surface of the thin film, at least the surface layer of the thin film is melted by the applied energy and crystallized by cooling solidification under a hydrogen-containing atmosphere "; and "wherein unpaired bonding electrons on the surface of the thin film during the cooling solidification are terminated by hydrogen atoms in the hydrogen-containing atmosphere" (emphasis added). Support for the amendments to claim 1 can be found, for example, at page 9, line 36 to page 11, line 15 of the specification. Claim 1 is neither taught nor suggested by the applied references.

Zhang crystallizes an amorphous silicon film by the use of a lower energy source. Zhang forms a catalytic substance on a substrate and then forms an amorphous silicon film contacting the substance. The substance acts as a catalyst during annealing of the amorphous silicon film, causing crystallization of the amorphous silicon film to occur at a low temperature. Zhang places the substrate, substance and amorphous silicon film in an

atmosphere and applies low energy to the substrate, metallic material and amorphous silicon during annealing. The substrate, catalytic substance and amorphous silicon film are subjected to the same temperature during annealing. Zhang does not melt any portion of the amorphous silicon. Thus, Zhang's energy source does not melt at least a surface layer of the amorphous silicon film during the annealing.

Zhang also does not teach or suggest that any melting of at least a surface layer of the amorphous silicon film would be desirable. In fact, such melting would be undesirable. That is, if one of the catalytic metals, such as Ni, taught by Zhang were melted by the applied energy, the melted metal could spread and contaminate the process. One skilled in the art would not have somehow modified the Zhang process in such manner because this modification would have rendered the resulting process unsatisfactory for its intended purpose. In re Gordon, 221 USPQ 1125, 1127 (Fed. Cir. 1984).

Furthermore, because of the presence of the catalytic substance in Zhang, there would have been no reason to have heated the amorphous silicon film to a temperature sufficient to cause at least a surface layer to melt. Such temperature would exceed the temperatures required by Zhang to achieve crystallization. Thus, one skilled in the art would not have heated the amorphous silicon film to such higher temperatures for no apparent purpose.

Also, such required temperature to cause melting would exceed the temperatures taught by Zhang to be suitable for manufacturing semiconductor devices. See col. 9, lines 27-46 of Zhang.

In addition, the hydrogen-containing atmosphere taught by Zhang is different from that of the claimed invention. Zhang particularly does not teach or suggest that "unpaired bonding electrons on the surface of the thin film during the cooling solidification are terminated by hydrogen atoms in the hydrogen-containing atmosphere," as claimed.

The Office Action asserts that "selectively applying energy is a well known process," and that Nakamura discloses selective energizing through a window. However, Nakamura provides no motivation to modify the Zhang process to achieve the claimed invention. It is well established that there must be motivation to modify the Zhang process to attempt to achieve the claimed invention. In re Geiger, 2 USPQ 1276 (Fed. Cir. 1987).

Nakamura crystallizes amorphous silicon using an XeCl excimer laser in a hydrogen or hydrogen plasma atmosphere. See col. 4, line 33 to col. 5, line 35 of Nakamura. Nakamura does not teach or suggest melting a surface layer of the polycrystalline silicon during the crystallization process. Nakamura thus also does not teach or suggest that "unpaired bonding electrons on the surface of the thin film during the cooling solidification are terminated by hydrogen atoms in the hydrogen-containing atmosphere".

Moreover, Zhang and Nakamura's processes are different from each other and their teachings are not properly combinable. Zhang and Nakamura use different energy sources for distinctly different purposes. Nakamura provides no teaching, suggestion or motivation to somehow modify the Zhang process to apply energy to the surface of the Zhang amorphous silicon using the Nakamura energy source such that at least a surface layer of the silicon is melted and crystallized. This modification would have gone directly against the teachings of Zhang. There is no teaching or suggestion in either Zhang or Nakamura that such modification would achieve the results desired in Zhang, which utilizes a catalyst to cause the crystallization of the amorphous silicon at low temperatures without any such melting. In fact, as stated above, such modification would likely destroy teachings of Zhang.

Thus, claim 1 would not have been rendered obvious by Zhang and Nakamura. Claims 2 and 5-11 depend from claim 1 and accordingly are also allowable for at least the same reasons stated for claim 1.

Claim 12 is directed to a method of forming a crystalline film, which comprises "forming a semiconductor thin film having a surface on a substrate"; "crystallizing at least a surface layer of the semiconductor thin film by applying energy to the surface of the semiconductor thin film, at least the surface layer of the semiconductor thin film is melted by the applied energy and crystallized by cooling solidification under an atmosphere containing a gas containing the component element of the semiconductor thin film and hydrogen"; and "unpaired bonding electrons on the surface of the semiconductor thin film during the cooling solidification are terminated by hydrogen atoms in the atmosphere " (emphasis added). Claim 12 is also not rendered obvious by Zhang and Nakamura for the reasons stated above. Claims 13-18 depend from claim 12 and accordingly are also allowable.

Claim 20 is directed to a method of forming a crystalline film, which comprises "crystallizing at least a surface layer of the thin film by supplying high energy to the thin film under a hydrogen-containing atmosphere, at least the surface layer of the thin film is melted by the high energy and crystallized by cooling solidification, and unpaired bonding electrons on the surface of the thin film during the cooling solidification are terminated by hydrogen atoms in the hydrogen-containing atmosphere". Claim 20 also recites that "the high energy is supplied to the thin film with the introduction window disposed at a location resistant to adherence of components of the thin film when the high energy is supplied to the thin film" (emphasis added). Neither Zhang nor Nakamura teaches or suggests the recited method.

First, as stated above, Zhang and Nakamura fail to teach or suggest modifying the Zhang process to include the step of "crystallizing" as recited in claim 20.

Second, the Office Action asserts that Nakamura's Fig. 6 "places its window (#52) as far away as possible from the surface to be treated (#53 or #52) thereby there is no adherence or very minimal adherence of the components of the thin film when the high energy is supplied to the thin film." However, Nakamura provides no disclosure regarding the position of the window 52

through which laser light is passed onto amorphous silicon 53 and thus does not teach or suggest that the window is as far away as possible from the surface to be treated. The window is located at the top side of the apparatus in Fig. 6 of Nakamura; however, this does not establish that the window 52 is sufficiently separated from the amorphous silicon 53 "such that the introduction window disposed at a location resistant to adherence of components of the thin film when the high energy is supplied to the thin film," as recited in claim 20. Nakamura is completely silent regarding any specific spacing of the window and amorphous silicon, or even that this is a concern of Nakamura.

In contrast, the present specification explains that the introduction window needs to be sufficiently separated from the object material to be crystallized, as compared to the scattering range of the object material, so that the components of the object material hardly adhere to the introduction window. Nakamura does not disclose this features. The Office Action states no reason why this result would inherently occur in Nakamura. It is well established that inherency must be a necessary result and not merely one possible result; the mere fact that a certain thing may result from a given set of circumstances is not enough. In re Oelrich, 212 USPQ 323, 326 (CCPA 1981). The Office Action has not met this requirement to establish the asserted inherency.

Thus, Zhang and Nakamura would not have rendered obvious the method of claim 20. Claims 21-23 depend from claim 20 and accordingly are also allowable.

Independent claim 25 is directed to a method of forming a crystalline film. The claimed method comprises "crystallizing at least a surface layer of the thin film by supplying high energy to the thin film under a hydrogen-containing atmosphere, at least the surface layer of the thin film is melted by the high energy and crystallized by cooling solidification, and unpaired bonding electrons on a surface of the thin film during the cooling solidification are terminated by hydrogen atoms in the hydrogen-containing atmosphere". Claim 25 also

recites that "the high energy is supplied to the thin film with a distance between the introduction window and the thin film larger than a shortest distance between the wall and the thin film" (emphasis added). Neither Zhang nor Nakamura teaches or suggests the method of claim 25.

As stated above, neither Zhang nor Nakamura teaches or suggests the claimed step of "crystallizing".

In addition, the cited references also fail to teach or even suggest that "the high energy is supplied to the thin film with a distance between the introduction window and the thin film larger than a shortest distance between the wall and the thin film," as recited in claim 25. In fact, in Fig. 6 of Nakamura, the distance between the window and the silicon 53 appears to be smaller than a shortest distance between the wall and the silicon.

The Office Action provides no motivation to modify the Zhang apparatus such that "the high energy is supplied to the thin film with a distance between the introduction window and the thin film larger than a shortest distance between the wall and the thin film," as claimed. This claimed feature also contributes to reducing or preventing the adherence of components of the thin film on the introduction window when the high energy is applied to the thin film.

Thus, Zhang and Nakamura would not have rendered obvious claim 25. Claims 26-28 depend from claim 25 and accordingly are also allowable.

Independent claim 30 recites a method of forming a crystalline film, comprising "crystallizing at least a surface layer of the thin film by supplying high energy to the thin film under a hydrogen containing atmosphere, at least the surface layer of the thin film is melted by the high energy and crystallized by cooling solidification, and unpaired bonding electrons on a surface of the thin film during the cooling solidification are terminated by hydrogen atoms in the hydrogen-containing atmosphere". Claim 30 also recites that "the high energy is

supplied to the thin film under a pressure in a vicinity of the introduction window that is higher than a pressure in the vicinity of the thin film in the supply chamber" (emphasis added). Neither Zhang nor Nakamura teaches or suggests the claimed method.

First, the cited references fail to teach or suggest the recited "crystallizing".

Second, Nakamura teaches no specific relationships between the pressures in the vicinity of the window 52 and in the vicinity of the silicon 53. Thus, Nakamura does not specifically teach that the pressure in the vicinity of the window 52 is higher than in the vicinity of the silicon 53.

Therefore, Zhang and Nakamura would not have rendered obvious claim 30. Claims 31-33 depend from claim 30 and accordingly are also allowable.

Independent claim 35 also would not have been rendered obvious by Zhang or Nakamura for at least the same reasons as claim 30. Claims 36-38 depend from claim 35 and accordingly are also allowable.

Independent claim 40 is directed to a method of forming a crystalline film. Claim 40 recites the step of "crystallizing" as described above. Claim 40 also recites that "the thin film is irradiated with the high energy introduced into the supply chamber through the introduction window along a irradiation path in the supply chamber," "a part of the high energy enters the thin film, and another part of the high energy is reflected from the thin film along a reflection path in the supply chamber," "a gas flow is present in the supply chamber," and "the high energy is supplied to the thin film with (i) the gas flow from the introduction window to the thin film in approximately the same direction as the irradiation path, and (ii) the gas flow from the thin film in approximately the same direction as the reflection path" (emphasis added). Neither Zhang nor Nakamura teaches or suggests the method of claim 40.

First, the cited art does not teach or suggest the recited "crystallizing".

Second, in the Nakamura device shown in Fig. 6, the gas is introduced into the chamber 51 through the inlet 60 in a direction that is perpendicular to the path of the laser beam. Nakamura clearly does not teach a "gas flow from the thin film in approximately the same direction as the reflection path," as claimed. The Patent Office is requested to identify any disclosure in Nakamura that supports the assertion that Nakamura teaches or suggests a "gas flow from the thin film in approximately the same direction as the reflection path," as claimed. In the absence of such teaching or suggestion in Nakamura, the applied references clearly fail to support the rejection.

For the foregoing reasons, claim 40 would not have been rendered obvious by the applied references. Claims 41-43 depend from claim 40 and accordingly are also allowable.

Therefore, Applicants respectfully request that this rejection be withdrawn.

2. The Office Action rejects claims 46-49 under 35 U.S.C. §103(a) over Zhang et al. (U.S. Patent No. 5,403,772) in view of Nakamura (U.S. Patent No. 5,200,630) and JP 58-90722 ("JP '722"). Applicants respectfully traverse this rejection.

Claim 46 is directed to a method of forming a crystalline film. Claim 46 recites the step of crystallizing as discussed above. Claim 46 also recites that "the thin film is irradiated with the high energy introduced into the supply chamber through the introduction window along a irradiation path assumed in the supply chamber," and "the high energy is supplied to the thin film with the normal direction of the thin film shifted by an angle from the direction of the irradiation path." An embodiment of the claimed invention is shown in Fig. 4, in which the irradiation path is shifted by an angle from the normal line to the thin film. The applied references fail to teach or suggest the method of claim 46.

First, the applied art does not teach or suggest the recited "crystallizing". JP '722, like Nakamura, provides no teaching, suggestion or motivation to modify Zhang to include this feature.

Second, as explained in the paragraph bridging pages 23 and 24 of the present specification, the claimed invention permits an increase in the distance between the introduction window and the material to which high energy is supplied. Also, in the embodiment shown in Fig. 4, for example, the evaporated materials and scattered fine powder are effectively discharged through the exhaust port, which is closer to the material than the introduction window.

The Office Action admits that Zhang and Nakamura fail to teach or suggest that "high energy is supplied to the thin film with the normal direction of the thin film shifted by an angle from the direction of the irradiation path," as claimed. However, the Office Action asserts that JP '722 teaches this feature and that it would have been obvious to person having ordinary skill in the art to have combined the teachings of Zhang, Nakamura and JP '722.

JP '722 provides no motivation to modify the apparatus of Nakamura such that "high energy is supplied to the thin film with the normal direction of the thin film shifted by an angle from the direction of the irradiation path." JP '722 shows in Fig. 2 energy being directed onto polycrystalline silicon 3. Single crystal regions 3' are formed. For example, in Nakamura, the exhaust opening 61 is disposed on a wall of the apparatus opposite to the wall at which the window is located. Thus, shifting the normal direction of the amorphous silicon 53 by an angle from the direction of the irradiation path of the light emitted by the laser 59 would not appear to enhance the discharge of any evaporated materials and scattered fine powder through the exhaust opening 61. That is, this modification of the Nakamura apparatus would not appear to affect the distance between the amorphous silicon and the exhaust port.

The Office Action asserts that this modification of Nakamura's apparatus according to the teachings of JP '722 would "more evenly and quickly irradiate the thin films." However, the Office Action provides no basis for this assertion.

Thus, the applied references would not have rendered obvious claim 46. Claims 47-49 depend from claim 46 and accordingly are also allowable.

Thus, this rejection is overcome and Applicants respectfully request that the rejection be withdrawn.

3. The Office Action rejects claims 56-62 under 35 U.S.C. §103(a) over Zhang et al. (U.S. Patent No. 5,403,772) in view of Nakamura (U.S. Patent No. 5,200,630) and JP 163406 ("JP '406"). Applicants respectfully traverse this rejection.

The Office Action admits that Zhang and Nakamura do not teach the claimed feature that "when a first position of the thin film is irradiated with the high energy introduced into the supply chamber, part of the high energy enters the thin film" and "another part of the high energy is reflected by the thin film to form reflected energy that irradiates a second position of the thin film through a course change of the reflected energy."

JP '406 fails to cure the omissions of Zhang and Nakamura with respect to claim 56.

First, the applied references do not teach or suggest the recited "crystallizing". JP '406, like Nakamura, provides no teaching, suggestion or motivation to modify Zhang to include this feature.

Second, the Office Action asserts that JP '406 shows "a part of the high energy is reflected by the thin film to form reflected energy that irradiates a second portion of the thin film" in Figs. 4, 6 and 8. However, Figs. 4, 6 and 8 do not show a thin film that reflects energy such that a reflected part of the high energy irradiates a second portion of the thin film. That, is the figures do not show the same thin film being irradiated with two separate high energy beams, one beam being a high energy beam that has previously been reflected by the thin film.

Thus, claim 56 is believed to be allowable. Claims 57-61 are also allowable for at least the same reasons as claim 56.

Claim 62 is directed to a method of manufacturing a thin film electronic device comprising a crystalline film formed by the method of claim 1. Accordingly, claim 62 also

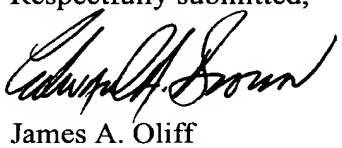
would not have been rendered obvious by the applied references for at least the reasons stated above for claim 1.

Therefore, Applicants respectfully request that this rejection be withdrawn.

For the foregoing reasons, withdrawal of the rejections and allowance of the pending claims are respectfully requested.

Should the Examiner believe anything further is desirable to place the application in even better condition for allowance, the Examiner is invited to contact Applicants' undersigned attorney at the telephone number listed below.

Respectfully submitted,



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